SILVERIZED CATGUT.

A STUDY OF THE METHOD OF CRÉDÉ FOR STERILIZING CATGUT WITHOUT HEAT.

BY JAMES EDDY BLAKE, M.D.,
OF BROOKLYN, N. Y.

As is well known, Professor Crédé, of Dresden, has advocated the use of colloidal silver and silver salts in the treatment of various forms of infection, and also as a means for preventing infection. Many of these preparations are very efficient as antiseptic agents and are practically harmless. This is especially true of collargolum, which can be used intravenously in doses of 5 to 10 c.c. (1.25 to 2.50 drachms) of a 1 per cent. solution.

By treating catgut with colloidal silver the catgut itself is not only made sterile, but it becomes impregnated with an efficient and innocuous antiseptic agent which exercises a local inhibiting influence upon the growth of any bacteria which may have been introduced in the wound from any cause.

My personal observation during a visit paid to the clinic of Professor Crédé, substantiated the claims made for the advantage of such catgut for ligatures and sutures. I found that Professor Crédé used catgut sutures almost exclusively; that there was no post-operative infection attributable to the inefficient sterilization of the catgut, and, that post-operative infections from any cause were very rare. Crédé's treatment of the catgut was to impregnate it with colloidal silver, and preserve it dry; then, several days before use, it was placed in alcohol.

In the spring of 1905, while engaged in laboratory work in connection with the service of Dr. L. S. Pilcher in the Methodist Episcopal Hospital in Brooklyn, I undertook, *through his advice and by his direction, to test specimens of* catgut prepared in a manner similar to that of Crédé. The tests covered a period of several months, and the present paper records the results of these observations.

Collargolum is simply metallic silver prepared in such a manner that it is soluble in water, but not diffusible through animal membrane. It was first described by Lee, in 1889, but was first prepared in a form practicable for use by Professor Crédé several years later. It occurs as simple, hard, brittle, bluish-black, scale-like pieces, which are soluble in water to the extent of 1 to 20; the solution being dark olive-brown in color and remaining stable for months.

No silver particles can be distinguished in the solution when observed under the highest powers of the microscope. It is not diffusible, and, in contradistinction to other inorganic bodies, the addition of albumin to collargolum prevents or delays the precipitation of acids and salts. A sufficient amount of albumin is therefore added to the collargolum during its manufacture to prevent its precipitation under ordinary conditions. Collargolum is unaffected by boiling; but boiling is quite unnecessary, as the solution is itself antiseptic.

" Collargolum may be introduced into the system intravenously, subcutaneously, endermically, or by mouth or rectum. Introduced intravenously it circulates in the blood for about eight to ten hours, and is then deposited in the organs or eliminated. It appears to be excreted through the intestines and kidneys, and never produces argyria. The elimination of silver is greatest during the first days. It can be detected after a week, and only after a month disappears entirely.

" No matter by what method the silver is introduced into the body, it exerts a markedly antiseptic action, and directly combats septic infection, whether due to staphylococci, streptococci, or similar bacteria, alone or combined with the bacteria of decomposition, which intensify the action of the pyogenic bacteria."—" Colloidal Metals in Medicine." Brochure. J. L. Berger, Berlin, 1904.

Collargolum therefore fills a very important place in the combatting of septic disease, and its marked usefulness is attested by a large and growing literature both German and foreign.

Our first test was directed to determine whether there would be any advantage in soaking the catgut in ether before immersing it in the collargolum solution. A strand of catgut was divided in half and each half was wound on a glass spool; one spool was placed in ether for five days, the other was kept dry. Both were then immersed in a 1 per cent. solution of collargolum. Two days later, a section was removed from each spool; but neither was thoroughly impregnated with the silver, as shown by the failure to darken in the centre on exposure to light. The corollary to this fact was revealed by later experiments: namely, that two days' immersion in the silver solution was insufficient to sterilize the catgut in all cases. Sections removed four days later were found to be thoroughly impregnated. A couple of strands removed at this time were left lying on the laboratory desk, exposed to the dust and air, until used for subsequent experiments some weeks later. On the twelfth day the spools were removed from the collargolum solution, washed in running water, and placed in a covered glass dish. This was clean but not sterilized. No precaution was taken in handling the spools to prevent contamination.

This test failed to reveal any advantage to be derived from the preliminary soaking in ether. The non-etherized catgut absorbed the silver solution quite as readily as the other; and in all subsequent tests the preliminary immersion in ether was omitted.

It was eleven days before any further tests were begun. On that day several short strands of catgut were removed from the non-etherized spool without any aseptic precautions. Two were placed in two bouillon tubes, and three in an agar tube. The spool was then placed in 95 per cent. alcohol. After twenty minutes, a piece was removed from the spool under aseptic precautions, washed in water, and divided into five parts; three of these were placed in three bouillon tubes; and the other two in an agar tube. At the same time one of the pieces that had been left lying on the desk exposed to the dust and air, but likewise to the direct sunlight, was cut in two, and one-half placed in a bouillon tube and the other half in an agar tube. All were then placed in the incubator at 37°. Of the nine tubes thus prepared, eight showed no sign of growth at the end of a month. One bouillon tube containing a section which had been removed without any aseptic precautions, showed slight growth at the end of the second day.

The spool from which the preceding tests were made, was allowed to remain in the 95 per cent. alcohol for two weeks. It was then removed and left lying on the laboratory desk. On the next day six short strands were cut off without aseptic precautions and placed in an agar tube. On the following day one strand showed growth at the tip end. Growth continued slowly from this point during the succeeding two weeks that the culture was observed. The other five strands remained sterile.

After lying on the desk for three days, the spool was soaked in alcohol for an hour and dried in the air for fifteen minutes. Sections were then placed in a bouillon tube and in an agar tube under aseptic precautions. Both tubes thus prepared remained sterile at the end of ten days.

For the purpose of making comparative tests, a spool of sterilized catgut was obtained from the operating room, and under all aseptic precautions sections were cut off and placed in three bouillon tubes and in an agar tube. Two short pieces were then cut off the same spool, drawn through unsterilized hands, and placed in two bouillon tubes. Sections of nonsterilized catgut were likewise placed in three bouillon and in an agar tube. On this same morning, Dr. L. S. Pilcher cut off two pieces from a strand of plain sterilized catgut, and two from a strand of chromic catgut that he was using during an operation, and dropped these into four culture tubes, two of bouillon and two of agar. A piece of silverized catgut which had been lying on the desk for five weeks was likewise dropped into a bouillon tube and all fifteen tubes placed in the incubator.

On the following day all three tubes containing the non-sterilized catgut showed heavy growth; so also did the two tubes containing the sterilized catgut that had been handled. Two of the tubes containing supposedly sterile catgut showed moderately heavy growth, the other two slight growth. The two agar tubes containing the sterilized catgut and the one containing non-sterilized catgut also showed beginning growth. Both the bouillon and agar tubes containing the chromicized catgut failed to show evidence of growth, and this remained true a week later. The tube which contained the silverized strand failed to show growth on the following day; but on the fourth day there was slight growth. Evidently the amount of silver present was insufficient to prevent all growth after such prolonged exposure to contamination.

Convinced by these tests that the silver solution was not only capable of sterilizing catgut, but also that it was capable of exerting a very marked inhibitory effect on the growth of bacteria adhering to the surface as a result of subsequent infection, our next tests were directed to the determination of the length of time necessary to ensure complete sterilization.

Before describing these experiments, a couple of points should be noted in reference to the preceding tests. All the silverized strands tested proved to be sterile except three. Of these three, one had been exposed to dust and air for weeks; and the other two had been cut off the sterilized spool with unsterilized scissors. The single test made on the chromic catgut showed it to be sterile. The six tubes containing supposedly sterile catgut all showed growth on the succeeding day. The corollary to this fact was discovered in a severe case of infection following suture for ununited fracture, and investigation showed that the catgut used at the operation and for the tests was from the same lot. No detailed investigation was made of the nature of the infection in the catgut, but from stab gelatine cultures and microscopic examination we concluded that we had present the staphylococcus aureus and albus, and an undetermined variety of bacillus.

During the succeeding weeks numerous tests of chromic and plain sterilized catgut were made. The results were practically the same as the preceding. The chromic catgut appeared to be sterile in all cases; the plain sterilized was frequently infected. The plain sterilized catgut has been prepared by boiling in alcohol after the method of Fowler.

On May 27, strands of heavy, medium, and fine catgut were wound on separate spools and placed in a 2 per cent. collargolum solution. They were removed at varying intervals and tested as follows:

(1) May 29. Sections were removed from each spool, washed in running water from the boiler, immersed in alcohol for five minutes, dried in the air, and dropped into tubes of bouillon. On the next day no growth was apparent. On the following day there was growth in the tube containing the medium catgut. On the second day thereafter there was heavy growth in this same tube. At the end of two weeks there was no growth observable in either of the other two tubes.

(2) Sections removed from the collargolum at the same time, and treated in the same manner as the preceding, except that they were left in the alcohol twenty hours. At the end of the second day, the tube containing the medium catgut showed slight growth. The other two tubes remained clear at the end of two weeks.

(3) May 30. Sections of catgut were removed from each spool, washed in hot tap water and placed in alcohol.

(4) May 31. Sections removed from the spools and treated as the preceding.

(5) June 2. Sections prepared as the preceding.

Owing to a delay in obtaining culture media, it was ten days before these sections were placed in bouillon tubes. But as cold alcohol is insufficient to sterilize catgut, this delay could not have materially modified the result. All the tubes thus prepared remained sterile at the end of two weeks.

(6) June 5. Sections were removed from the spool of medium catgut, washed in tap water, and left in the covered glass dish for a week. They were then handled by Dr. Pilcher, without his having sterilized his hands, and were then placed

in three bouillon tubes. On the second day there was slight cloudiness in one of the tubes; but it did not increase. The silver present had apparently checked the further growth. At the end of two weeks all three tubes were perfectly clear.

(7) June 5. A strand of sterilized catgut was obtained from the operating room and handled as the preceding. It was then divided into three pieces and these were placed in three bouillon tubes. On the third day thereafter, two tubes had become cloudy, and the third contained a flocculent precipitate. At the end of a week, growth had increased slightly in all. At the end of two weeks, two tubes were very cloudy; the third contained a heavy precipitate.

The results of these tests may be thus briefly summarized: Perfect sterilization was sometimes achieved after two days' immersion in the silver solution, and always after three days' immersion. Catgut thus prepared showed a very marked resistance to subsequent infection, and, likewise, a marked inhibitory influence upon the growth of bacteria introduced with it into the bouillon solutions. This inhibitory influence was much less marked in the agar tubes. To obtain it, a partial dissolving out of the silver appears necessary, and this is exactly what occurs both in the bouillon tubes and in the tissues.

Encouraged by the favorable outcome of these experiments, our next step was to employ silverized catgut at an operation.

Several spools of medium-sized catgut were placed in a 2 per cent. collargolum solution, and left for five days. They were then washed in sterile water, dried for a few minutes in the air, and then placed in 95 per cent. alcohol. A couple of days later, catgut from these spools was used as the ligature and suture material at an operation for removal of tubercular glands of the neck. Two agar and two bouillon tubes were prepared from short sections cut from ends remaining after tying the ligatures.

Recovery after the operation was prompt and uneventful. The wound showed no sign of irritation and healed by primary intention. All four tubes containing the samples of catgut employed at the operation, remained sterile after the lapse of ten days.

During the next week, the silver catgut was only used in selected cases, mainly those involving superficial operations. Since then, in the service of Dr. Pilcher, it has entirely replaced the plain sterilized catgut, for all purposes for which the latter is commonly employed.

During the earlier portion of this period, the silver catgut was repeatedly tested, but always found sterile.

Numerous tests were made as to the most suitable strength of the collargolum solution, and as to whether the same solution could be used twice in succession. We found that after the first time, the silver became precipitated, so that it no longer impregnated the catgut quickly and evenly. It is therefore advisable to place the maximum amount of catgut in the minimum of solution, but it must be rolled upon the spools before being placed in the solution.

For a time it was noted that the catgut when removed from the spool was a trifle soft and hard to thread; whereas a few minutes later it would be hard and almost wiry. The cause of this was found to be an error in technic. The catgut as it comes out of the collargolum solution is quite as soft as after soaking in plain water. In order to dry it, it is necessary to expose it to the air until the silver is deposited as a metallic sheen. If placed in the alcohol too soon, this change does not occur, until it is once more exposed to the air as at operation.

It was my purpose to make a number of tests of the relative tensile strengths of plain sterilized, chromic, and silverized catgut; but my investigations were interrupted after only one test had been made. This test was as follows: Strands of chromic, silverized, and plain sterilized catgut of medium size were each divided into two pieces, marked A, and B. The ends of each piece were tied together separately, making six loops. The loops were then placed on spools, and the tensile strength noted. The result thus found is that of two strands, or double that of one strand. In every case the knots were so placed that they did not receive the full force of the strain. The point at which A broke having been noted, the broken ends were tied, and the piece again tested. The point at which the strand broke having again been noted, the longer piece was again tied in a loop, placed in water for fifteen minutes, and again tested. The strands marked B were immersed in water for thirty minutes and then tested. The results may be summarized as follows:

CHROMIC.	
Aa broke at (knot)	19 pounds
Ab broke at	22 pounds
Ac broke at	18 pounds
B broke at	14 pounds

SILVERIZED.	
Aa broke at	20 pounds
Ab broke at	20 pounds
Ac broke at	16 pounds
B broke at	13 pounds

PLAIN STERILIZED.	
Aa broke at	20 pounds
Ab broke at	18 pounds
Ac broke at	9 pounds
B broke at	9 pounds

In other words, the silverized catgut appeared to be slightly stronger than the plain sterilized catgut, and slightly weaker than the chromic catgut. After immersion in water for fifteen minutes, the chromic catgut lost about 14 per cent., the silver catgut 20 per cent., and the plain sterilized catgut about 50 per cent. of the tensile strength. After thirty minutes' immersion in water, the chromic catgut had lost 33 per cent., the silverized 35 per cent., and the plain catgut 50 per cent. of the original tensile strength.

Although this single test fails to prove anything, it nevertheless corroborates the clinical evidence which shows that the silverized catgut is but little if any inferior to the chromic catgut in tensile strength and resisting qualities, and is very markedly superior to plain sterilized catgut in both these qualities.

In the preparation of the catgut for use, the method employed is as follows: Four coils of catgut, each containing ten strands, are wound on four glass slabs, and placed in a jar containing a 2 per cent. solution of collargolum. They remain in this about a week, the jars being shaken once or twice in the interval. The slabs are then removed, washed in sterile water until the excess of collargolum solution is removed, and placed in 95 per cent. alcohol for fifteen to thirty minutes. After this the separate strands are wound on separate spools, under aseptic precautions, and preserved in 95 per cent. alcohol until used. Four coils are employed as the unit, as they exactly fill the jar containing the collargolum solution; and as many jars are prepared at any one time as may be necessary.

[NOTE BY DR. PILCHER.—Since the demonstration by Dr. Blake of the reliable qualities of silver preparation in rendering catgut not only aseptic, but also to a certain degree antiseptic wherever buried in a tissue, it has been used in all cases in my operative work at the Seney Methodist Episcopal Hospital, amounting in number to more than 500 operations, and has continued to give me abundant satisfaction and to justify, clinically, all the expectations which the laboratory experiments of Dr. Blake had suggested.

During this period there has been a notable absence of infective accidents in an active general service which has included nearly every variety of operative interference. Silverized catgut has become established as a permanent factor in our operating-room methods.

The method of preparation is simple and reliable, and may be commended to a further trial by surgeons.

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